

## VERTEBRAL FIXING SYSTEM

The present invention relates to a vertebral fixing system adapted to be mounted on a vertebra, and to a spine-straightening assembly using the system.

5 One field of application that is envisaged, is particularly but not exclusively, the treatment of scoliosis or, more generally, the correction of abnormal curvatures of the spine.

The spine is formed of superposed vertebrae, normally aligned along a vertebral axis, from the lumbar vertebrae to the cervical vertebrae, and each having a posterior wall from which projects a spinous process and two lateral edges from the walls of which there project ribs and/or transverse processes. If the spine of a person has abnormal curvature, the vertebrae are inclined relative to each other and relative to said vertebral axis. The lateral edges of the vertebrae on one side are therefore closer together and form a concave shape while the lateral edges on the other side are farther apart and form a convex shape.

To straighten the vertebral column, the lateral edges of the vertebrae on the concave side are moved away from one another and supported at distances from one another substantially equivalent to the distances between the lateral edges on the other side. Devices known in the art are used thereafter to hold the vertebrae relative to one another, and comprise screws that are inserted into the vertebrae or hooks that are inserted along the internal wall of the spinal canal and rods adapted to connects the screws or hooks.

Pairs of hooks are generally inserted into each vertebra, one on each side, near the pedicle; they have heads that project from the posterior wall of the vertebra, one on each side of the spinous process. The heads are tulip-shaped, for example, and are adapted to receive a rod that is immobilized by a nut that is screwed onto the head and bears on the rod. The heads of

the hooks situated on either side of the spinous process are connected together and fixed in position by two rods parallel to each other and to the axis of the spine.

5 However, using such hooks is difficult because the operative must not under any circumstances touch the spinal cord that extends along the centre of the spinal canal, since that would result in paralysis of the patient.

Using screws reduces the risks of the procedure.  
10 The screws also have tulip-shaped heads and are inserted in pairs into the pedicles on each side of the spinous process on the posterior wall of the vertebrae. The screws therefore constitute fixing points on the vertebrae for holding them relative to one another.  
15 However, they must be inserted into the pedicles of the vertebrae, which in some cases are small or have deteriorated.

A problem that arises, and that the present invention aims to solve, is that of providing fixing  
20 points when it is not possible to insert screws into the vertebrae in the abnormal curvature region and when using hooks is too dangerous.

To achieve the above object, a first aspect of the present invention proposes a vertebral fixing system that  
25 comprises: a connecting part adapted to face said rib and/or said transverse process and to be connected to said rod, an elongate flexible ligature adapted to connect together said connecting part and at least one rib and/or one transverse process, and adjustable locking  
30 means fastened to said connecting part and adapted to fix simultaneously in position said connecting part relative to said rod and at least one portion of said ligature relative to said connecting part, so as to prevent relative displacement of said rod and said vertebra in  
35 opposite directions.

Thus one feature of the invention resides in the method of connecting said rod with said vertebrae using

the connecting part that connects together the flexible ligature and said rod. The ligature, one end of which is connected to said rib and/or transverse process, is adapted to be immobilized in said connecting part by the adjustable locking means, which also fix said connecting part in position relative to said rod, with the result that relative displacement of said rod and said vertebra is prevented, at least in the opposite direction.

In a first embodiment of the invention, said connecting part includes a passage facing said rod and said ligature passes through the adjustable locking means to reduce the section of said passage in order to press said ligature against said rod and simultaneously to fix said connecting part and at least one portion of said ligature in position relative to said rod.

As a result of this feature of the invention, said ligature is adapted to be wedged between the wall of the passage in the connecting part and the wall of said rod and, at the same time, said connecting part is adapted to be fixed in position relative to said rod. As a result, it is only the action of the adjustable locking means that fixes the ligature in position and immobilizes the connecting part relative to said rod.

In one particularly advantageous embodiment of the invention, said ligature has a first end fastened to said connecting part and a free second end adapted to slide in said connecting part and to be formed into a loop, a portion of said ligature between said ends being adapted to be immobilized in translation relative to said connecting part by said adjustable locking means, whereby the loop has a particular length.

Thus the ligature is formed of two sections. One end of the ligature is fixedly clipped to the connecting part, the ligature is then stretched around the rib and/or the spinous process, and the free second end of the ligature is then inserted into said connecting part. The first section of the ligature is the part that

extends from the second end into contact with the rib and/or the transverse process and the second section is the part that extends from the rib and/or the transverse process to the connecting part. As a result, the free  
5 end may be stretched to hold said connecting part against the vertebra, said rod and said ligature being adapted to be locked together by adjustable locking means.

It is preferable if said connecting part comprises two longitudinal members whose first ends are connected  
10 together so that said members may pivot relative to each other and the middle parts of their two facing faces are adapted to bear on respective opposite sides of said rod, said adjustable locking means being adapted to drive the second ends of said longitudinal members forcibly towards  
15 each other and to fix them in position relative to each other so that said two members form a clamp and grip said rod, whereby said connecting part may be fixed in position relative to said rod.

The two longitudinal members articulated to each  
20 other at their first end form a clamp such that the two middle parts of the two facing faces may be driven towards each other and grip said rod. The adjustable locking means hold the two longitudinal members pressed onto said ligature and against said rod.

It is particularly advantageous if said second ends  
25 of the two longitudinal members have, facing each other, a bore in one and a thread in the other, so that a screw may be passed through said bore and screwed into said thread and form said adjustable locking means.

Turning the screw after it has been passed through  
30 the bore and screwed into the thread therefore forcibly drives the second ends towards each other. The force immobilizing said connecting part relative to said rod and said ligature is a function of the clamping force  
35 applied by said screw.

In one particularly advantageous embodiment, said first end of said ligature is fastened to the pivot of

said longitudinal members. The tension force applied to said ligature is therefore substantially equally divided between the two first ends of said longitudinal members.

It is preferable if at least one of the middle parts of said two facing faces has a first portion through which said passage passes and a second portion adapted to bear against said rod. Accordingly, said second portion of said longitudinal members of the connecting part is adapted to bear on and to be in direct contact with said rod whereas the first portion of the middle parts presses said ligature against said rod. Said connecting part is therefore perfectly fastened to said rod and fixed in position relative to it and at the same time a portion of said ligature is perfectly wedged between said rod and the wall of said passage.

It is particularly advantageous if said passage extends between two orifices in said connecting part and opening to the outside of said part so that said ligature is able to slide through said part.

Said ligature is therefore perfectly guided inside said connecting part in said passage with the result that stretching of the free second end of said ligature cannot divert said ligature from said passage, regardless of the driving angle relative to said connecting part. During the stretching of said free second end of said ligature, the adjustable locking means immobilize at least a portion of said ligature.

It is preferable if each of said middle parts of said two longitudinal members includes an orifice. Said free end of said ligature can then be inserted into one of the two orifices, stretched in the passage that extends between the two longitudinal members and said rod, and extracted via the second orifice so that it may be stretched. Pressing the two longitudinal members against said rod therefore immobilizes the ligature against the rod.

In one particularly advantageous embodiment, said

passage has a section that decreases from one orifice to the other so as to be able to exert a progressive pressure on said ligature portion between said two orifices to press it against said rod.

5           Thus, according to this feature, the pressure of said ligature on the rod may be controlled by the adjustable locking means so that the free second end of said ligature may be forcibly stretched, to tension it. Once it has been tensioned, the adjustable locking means  
10           may be operated to immobilize the ligature completely relative to the rod and to immobilize the connecting part relative to the rod. The loop formed around the rib and/or the transverse process by said ligature is therefore of fixed size and maintains the tension in said  
15           connecting part facing the posterior wall of said vertebra.

Other features and advantages of the invention will emerge upon reading the description given hereinafter and with reference to the appended drawings of particular  
20           illustrative but non-limiting embodiments of the invention, in which drawings:

- 25           - Figure 1 is a fragmentary diagrammatic perspective view showing a vertebral fixing system of the invention and a rod,
- Figure 2 is a diagrammatic view in vertical section of the subject matter of the invention mounted on a rod,
- Figure 3 is a diagrammatic perspective view in section of the subject matter of the invention, and
- 30           - Figure 4 is a diagrammatic view in elevation of the subject matter of the invention mounted on a vertebra.

Figure 1 shows a vertebral fixing system of the invention mounted on a rod 10. The vertebral fixing  
35           system comprises a connecting part 12 having two longitudinal members, of which a first longitudinal member 14 extends between a first end 16 and a second end

18 and a second longitudinal member 20 extends between a first end 22 and a second end 24. The two longitudinal members 14 and 20 are pivoted together at their first ends 16 and 22 for the purposes of mounting the system.

5 The first end 16 of the longitudinal member 14 has a notch 26 with two opposite edges 28 and 30 and between which the first end 22 of the other longitudinal member 20 may be inserted. A pivot pin 32 passes through the two first ends 16 and 22 and is free to rotate in at least one of said ends 16 and/or 22. The second end 18 of the first longitudinal member 14 includes a bore 34 into which a screw 36 may be inserted. The second end 24 of the second longitudinal member 20 comprises a thread 38 which is aligned with said bore 34 when the two longitudinal members are disposed facing each other, with the result that the screw 36 may be screwed into said thread 38 in order to drive the second ends 18 and 24 of the two longitudinal members 14 and 20 towards each other. The consequences of screwing said screw 36 into the thread 38, thereby forming the adjustable locking means, are explained in more detail hereinafter. Figure 1 also shows a first orifice 40 through which a ligature may be stretched. The method of connecting said ligature to said connecting part is described with reference to

25 Figure 2.

Figure 2 shows again the connecting part 12 consisting of the first longitudinal member 14 and the second longitudinal member 20, said longitudinal members 14 and 20 pivoting about the pin 32 that joins them. The adjustable locking means consisting of said screws 36 passing through the bore 34 and screwed into the thread 38 immobilize said connecting part 12 relative to the rod 10 and fix in position a portion of a ligature 42 shown in part in Figure 2.

35 The ligature 42 consists of an elongate flexible member capable of conforming to the contour of the parts that it must connect.

The ligature 42 has a first end 44 that is ligated around the pin 32 and a free second end 46 that is inserted into a passage 48 between the rod 10 and the internal walls 50 and 52 of the longitudinal members 14 and 20 and the external wall of the rod 10. As shown in Figure 2, the second longitudinal end 20 includes a second orifice 54 through which said ligature 42 passes. Moreover, as shown in Figure 4, the ligature 42 may be formed into a loop 56 in which the transverse process is trapped. Clearly, where applicable, the ligature 42 may also trap the rib.

As shown in Figure 3, which shows again the second longitudinal member 20, the middle part has a first portion 56 through which said passage 48 passes and a second portion 58 adapted to bear directly on the rod. Accordingly, the passage 48, which is symmetrical inside the first longitudinal member 14, is produced by a groove formed in each of the two facing faces of the middle parts of the longitudinal members 14 and 20.

It is clear in Figure 3 that the first portion 58 of the middle part forms an edge with cylindrical symmetry and that the corresponding second portion of the middle part of the first longitudinal member 14 forms a substantially cylindrical space 60 into which said rod 10 is inserted.

Figure 2 shows that the second portion 58 of the middle part comes into contact with the rod and is adapted to bear on top of it and the first portion 56 presses the free second end of said ligature 42 against the rod 10. The adjustable locking means therefore drive the longitudinal members 14 and 20 forcibly against the rod 10 and simultaneously against the ligature 42, which is also forcibly pressed against the rod 10.

It is particularly advantageous if, as shown in Figure 2, the passage 48 has a section S1 in the vicinity of the orifice 54 greater than the section S2 in the vicinity of the first orifice 40, the section of said



passage 48 decreasing progressively in the direction from the second orifice 54 to the first orifice 40. The ligature 42 is therefore progressively compressed around a portion of the rod 10 with a pressure that increases in the direction from the second orifice 54 towards the first orifice 40.

Figure 4 shows a vertebral fixing system of the invention mounted on a vertebra having a transverse process. This figure shows again the rod 10 and the two longitudinal members 14 and 20 that grip it and press a portion of the ligature 42 against said rod 10.

In Figure 4, the flexible ligature 42 consists of a flexible strip of substantially constant width and thickness whose first end is ligated to the pin 32, the ligature surrounding the transverse process of the vertebra being inserted through the connecting part 12. The section of the flexible strip 42 is substantially rectangular so that, the pin 32 and the rod 10 being substantially perpendicular to the transverse process, the ligature has to be partly twisted in order to insert it into the passage 48 and between the ligature 32 and the point at which it contacts the transverse process. The fixing system 12 is fixed in position against the posterior wall 60 of the vertebra despite these partially twisted portions, the ligature 42 being forcibly tensioned by stretching the free second end 46.

The ligature 42 is advantageously made from a flexible material such as polyester that may be lightly crushed locally to immobilize it with a clamping effect.

A second aspect of the invention relates to a spine straightening assembly comprising a plurality of vertebral fixing systems conforming to the present invention and mounted on a plurality of successive vertebrae, on all the transverse processes of one lateral wall thereof, and connected to a single rod that is disposed substantially parallel to said spine. The transverse processes of a portion of the spine can

therefore be connected together by a single longitudinal rod, to fix them in position relative to each other, by means of the above vertebral fixing system.